Oil spills: A large scale monitoring from Landsat

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OIL SPILLS : A LARGE SCALE MONITORING FROM LANDSAT

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ABSTRACT

Previous studies have shown that oil spills have been viewed by LANDSAT. The detection of oil is due to the variations of the reflection coefficient between the rough sea and the oil spill. This result is used in the framework of the ARCHIMEDES Project, lead by the Joint Research Center - Ispra, in order to inventory the hydrocarbons pollution in the Mediterranean Sea, from 1972 to 1975.
From a study of 800 images, we estimate the cumulative area covered by the hydrocarbons spread each year in the Mediterranean Sea to be about 175,000 km^2.

Keywords : Oil Pollution, Remote Sensing, Mediterranean Sea.

1. INTRODUCTION

In 1980, the Council of Ministers of the European Communities had approved the ARCHIMEDES Project. The long term objectives of this programme are :
- Research on the detection and identification of type of hydrocarbons.
- Research on the propagation of chemical substances along coastlines.
- Co-ordination between Joint Research Center and the relevant European research laboratories to develop the means and experience required to define meaningful pilot studies.
- Collaboration with other agencies on intercalibration and sampling programmes.

As a leader of this project, Joint Research Center Ispra entrusted our laboratory with a preliminary inventory and mapping of the hydrocarbons pollution of the Mediterranean Sea from the LANDSAT imagery.

2. VIEWING OF OIL SPILLS BY LANDSAT

Several authors have reported on the viewing of oil spills by LANDSAT. The difference between the reflection coefficients of a rough sea and of a calm one allows for the detection of an oil spill. While an oil spill is flattening the sea and reflects only in one direction, the capillary waves of a rough sea scatter the light and a fraction of the incident light reaches the satellite.
From the Cox and Munk's model, we have computed the reflection coefficients and the glitter reflectances for a calm sea (wind of 5 m/s) and for a rough sea (wind of 14 m/s). As the wind becomes stronger than 7 m/s, foam appears and increases the reflection coefficient. We have introduced the presence of white caps in the reflection model by assuming a foam albedo of 50 % and a foam coverage of 7 % for wind of 14 m/s. The model is sensitive to the observationnal geometry, i.e. to the sun and satellite zenith and azimuth angles. In figure 1 are represented the glitter reflectances computed throughout the year for mean sun time 10h30 and for latitude 45° N. This corresponds to the LANDSAT overpasses.
As the MSS 7 channel of LANDSAT can measure a difference of reflectance of about 1 %, one can see that MSS 7 can easily detect the variations of the sea-state, except during winter where rougher sea states are required to be observable. However, this period is very cloudy and no routinely satellite survey is possible.
We can consider an oil spill as a calm sea, because their optical properties in the MSS 7 channel are equivalent. Thus, WE CAN SURVEY THE HYDROCARBON POLLUTION AT SEA, using the LANDSAT MSS 7 CHANNEL. But we expect to underestimate the pollution level in winter, because of the low elevation sun angles, and to have a good estimation during the rest of the year.

3. MEDITERRANEAN SEA INVENTORY RESULTS

We have applied this model to the Mediterranean Sea. Owing to the kindness of Pr APEL and of his staff, we have examined about 800 LANDSAT images, obtained during the last six months of 1972 and the years 1973 and 1975.
Each image was interpreted for the presence or the absence of oil spill. Oil spill cannot be confused with areas of wind shadow, because the limits of these areas are very diffuse and these areas are often connected to the coastlines. We take care also not to count twice a spill. The mean area covered by the spills displayed on one scene is about 100 km.
For the whole data set, the percentage of images showing hydrocarbons films is more than 50 %. This percentage varies along the year. It reaches its maximum during June and falls strongly in November, according to the reflection model.
It would then be attractive to estimate the cumulative area covered by the oil spread each year in the Mediterranean Sea. If we neglect evaporation, biodegradation and oil sink, and assume that the detected spills are very recent, we obtain a rough

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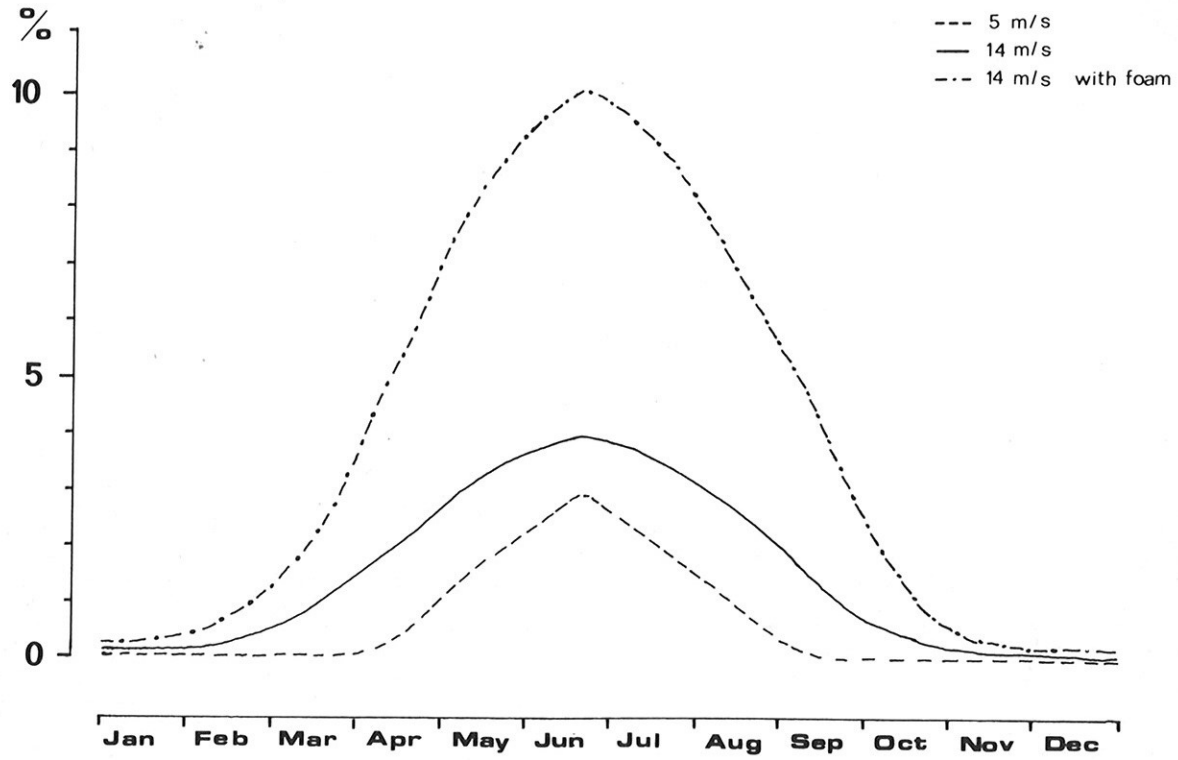

Figure 1. Glitter reflectance observed by LANDSAT for a non-turbid atmosphere throughout the year for various sea states. The lower curve is for a wind speed of 5 m/s, the full line is for a speed of 14 m/s, and the upper curve is for the same speed but when foam is taken into account. Latitude is 45° N, and mean sun time is 10h30.

estimation of the cumulative area of order of 175,000 km^2.

4. ACKNOWLEDGMENTS

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